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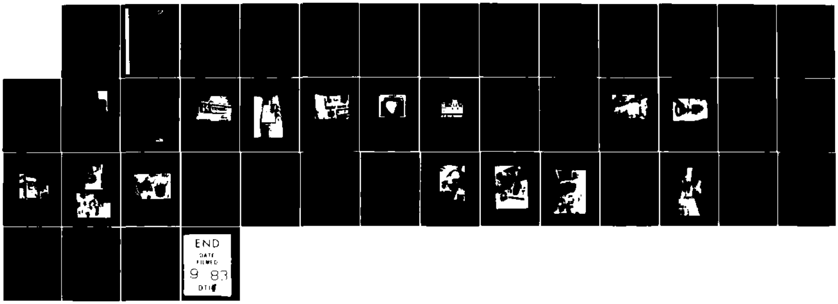

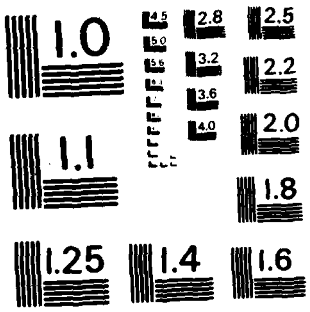

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DEPARTMENT OF DEFENCE SUPPORT

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AERONAUTICAL RESEARCH LABORATORIES

MELBOURNE, VICTORIA

AERODYNAMICS NOTE 412

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SUMMARY

The ARL transonic wind tunnel is described. Originally built as a conventional subsonic high-speed tunnel it was converted in 1957 to transonic operation, and has been in operation since that time.

It is a continuous flow, closed circuit tunnel with an electric drive system whose maximum power input is 2050 kW. The test section is 0·81 m high and 0·53 m wide. It is fitted with slotted walls and uses diffuser suction, covering a Mach number range of 0·4 to 1·4.

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CONTENTS

1. INTRODUCTION

In the early 1940's, when ARL was part of the Council for Scientific and Industrial Research (now CSIRO) the ARL transonic wind tunnel was built as a variable-pressure, high-speed, subsonic, continuous flow wind tunnel. At the time of its construction, equipment was difficult to obtain and an existing Ward Leonard set was used for its drive. Later, the tunnel drive was replaced by a "Merlin" aircraft internal combustion engine, giving about 750 kW. Finally, in 1957, the tunnel was modified to operate transonically.

The first two configurations are described briefly, partly as a matter of historical interest, and partly as necessary background for the subsequent description of the present tunnel.

2. ORIGINAL SUBSONIC TUNNEL

The aerodynamic outline of the original tunnel is shown in Figure 1 and the drive arrangement in Figure 2. This drive was controlled by a Ward Leonard set of 112 kW continuous rating, with the DC motor driving a contra-rotating fan (Fig. 3) through a three-speed gearbox. The three-speed box was intended to match the drive to the varying tunnel conditions. The tunnel pressure could be varied from 0 to 6 atmospheres and the three-speed box was intended to give high Reynolds number test conditions at low speeds, and high speeds at low pressures, with the middle speed for in-between conditions. Two test sections, with contractions and first diffusers to match, were provided, one circular, 0·61 m (2 ft) in diameter, the other rectangular, 0·381 m by 0·813 m (15" by 32"). The latter was intended to use flexible top and bottom walls, whose settings were made by small motors driving jacks through gearboxes. Wall shape was monitored by means of "Desynn" indicators. Figure 4 shows a view of one flexible wall during construction. The intention was, of course, to reduce interference in two-dimensional tests, by shaping the walls.

To keep turbulence in the test section small, six screens were fitted in the settling chamber and a large contraction ratio (25 : 1) was used. The contraction design[2] was based on the expression

$$(A/a)^4 = k(0{\cdot}25-0{\cdot}20y)y^4+1,$$

where

$$k = \{(A_0/a)^4-1\}\times 20,$$

where A_0/a is the contraction ratio,

A/a is the area ratio corresponding to y, and

y varies from 0 to 1.

To remove the loads associated with the tunnel operating pressure, the contractions, test sections and first diffusers were surrounded by a large plenum chamber, diameter 2·54 m (8′ 4"), which eventually turned out to be even more useful for transonic operation. All corners were constant spacing Collar type vanes of hollow plywood construction, with appropriate bleed holes to permit pressure equalization. Because of the high pressure rating, the whole shell of the tunnel was 12·7 mm (½") steel plate, suitably ribbed as required (see Fig. 5). Construction of this shell was completed in 1944. Tunnel cooling consisted of spraying water over the tunnel shell exterior to the building (Fig. 5), collecting the water in a "pond" under the tunnel and recirculating. The same water was used to cool tunnel auxiliaries. Total cooling was designed to be about 187 kW.

Dry air for the tunnel was provided using a drying tower 0·61 m in diameter and 3·35 m tall containing approximately 0·5 tonne of activated alumina. The tower was reactivated by sucking air, heated by a 3·5 kW electric heater to about 270°C, through the tower, and then

allowing to cool before use. For varying tunnel pressure, a 56 kW reciprocating compressor was available, and could also be operated as a vacuum pump to reduce pressure. A small piston type vacuum pump was also installed

A most ingenious scheme was developed for on-line computation and display of force coefficients, Mach number, Reynolds number and kinetic pressure. Four pressure manifolds were fitted to the contraction, and pressure differences measured using two special U-tube manometers (Fig. 6) with bores machined to a high degree of accuracy. The fluid displaced in the manometer was weighed by special electromagnetic devices.[3,4] The same devices were also used, one per component, to measure loads on the six-component external balance. They consisted of a coil operating in an annular gap in a large electromagnet, the face of the coil former and the top surface of the magnet forming a capacitance whose value depended on the distance between the two faces. This capacitance was one arm of a bridge supplied with 465 kHz and bridge out-of-balance voltage was amplified, rectified and fed back through the coil as direct current, restoring the unit almost to its original position, and providing a current proportional to the load applied to a high degree of accuracy.

Thus, two currents were produced by the pressure differentials, and six by the balance. The ratio of manometric currents could be used to provide Mach number[5] (Fig. 7), and with some circuitry, kinetic pressure and Reynolds number were produced. Thus, force and moment coefficients were also provided on ratio meters. For better accuracy, potentiometers were used to measure currents, and a voltage divider allowed Mach number to be preset and then tunnel speed controlled quite accurately. Part of the original control desk is shown in Figure 8.

A conventional multitube manometer, which could be photographed with an F-24 aircraft camera, thermocouples for temperature measurements, angle of attack indication, etc., were all provided, and, of course, being a variable pressure tunnel all settings and measurements were by remote control.

Initial aerodynamic calibration and investigation showed that the tunnel was satisfactory, but grossly under-powered. At that time funds were not available to provide a new electrical drive system of the power required.

3. OPERATION WITH "MERLIN" DRIVE

About 1950 it was decided to increase the input power by installing a "Merlin" aircraft petrol engine. It was considered that the cost would be comparatively small, and would permit the performance of the tunnel to be checked out adequately. The increased power and speed of the engine required a new gear box and an aircraft gearbox operated back to front, was used while a two-stage axial compressor designed to give the required pressure ratio and to operate over the appropriate range of r.p.m. was built and installed. The drive arrangement is shown in Figure 9, while Figure 10 shows the actual Merlin, gearbox and exhaust system.

The power increase (over 750 kW was available) rendered most of the existing instrumentation unusable, and so it was decided to use only the simplest possible instrumentation and get the tunnel working. It was found that the aerodynamic design of the tunnel was satisfactory and that it was possible to operate the tunnel up to Mach numbers approaching 1.

Operation with Merlin engines produced some unexpected side effects. Since the engine, on starting, reached around 1000 r.p.m. almost instantaneously, the compressor was usually stalled, and standard procedure was then to cut the motor (and so unstall the blades) and restart it at the right instant. At the other extreme, if the Merlin cut out at high r.p.m., it simply stopped dead, and apart from the disconcerting effect on tunnel operators, this also sent a large pressure pulse around the tunnel circuit. To alleviate the loading due to this pressure pulse large spring-loaded doors were fitted in the first diffuser. In addition, the exhaust system developed faults and in spite of numerous repairs, minor fires were not uncommon, while the noise level made communication extremely difficult even using head set and throat microphone type intercom systems.

Cooling water for the Merlin was provided by radiators and an air blower, but at full short-duration power the engine overheated in about 15 minutes. This matched the tunnel, which having only the original cooling, reached about 110 C in about the same time. Because

speed control relied on the Merlin throttle, reproduction of tunnel Mach number was not possible to conventional wind tunnel accuracy, although the stability of the drive was better than had been anticipated.

It was found that frequent repairs and engine replacements were necessary, and although this was probably due to the conditions under which the engines operated and the inevitable tunnel demand for more and more power, too much effort had to be devoted to drive maintenance. Nevertheless, useful testing was carried out and a complete aerodynamic investigation of the tunnel was made,[6] including the compressor performance. However, when it became possible to replace the temporary drive with an electric one, work on transonic test sections had commenced, and the new drive was delayed until power and pressure ratio requirements for transonic operation were known.

Since the tunnel possessed a large plenum chamber (Fig. 1) installation of a slotted test section appeared feasible and in 1951, such a test section was built and installed. At this time, all overseas work on ventilated test sections was classified. Consequently, no published information was available in this country until after the main tunnel modifications had been completed. Preliminary experiments showed that fairly extensive research would be needed to develop a satisfactory transonic facility. As a result, effort in the main tunnel ceased and a small pilot tunnel was used—initially as a blowdown tunnel using the main tunnel as a reservoir—and later as a continuous closed return tunnel using a Merlin supercharger driven with a 150 kW AC motor. Early work[7] used a circular slotted test section, but this was abandoned in favour of a rectangular one 51 × 102 mm (2″ × 4″), the contraction, test section and first diffuser being scaled versions of the rectangular configuration of the main tunnel. For this rectangular test section, for both two-dimensional[8,9] (i.e. two ventilated and two solid walls), and for four slotted wall configurations, the effect of slot shape and size, open area ratio, and diffuser inlet design on Mach number distribution, maximum Mach number and pressure ratio were investigated. Using auxiliary suction[10] and both porous and slotted walls, the same factors but excluding diffuser inlet and including suction mass flow, were determined.

From the above work, it was concluded that for the main tunnel, a porous walled configuration using the existing two-stage compressor plus auxiliary suction from the existing plenum chamber, and preferably having a flexible nozzle, was the most efficient and preferred arrangement. Accordingly, the whole design, auxiliary compressor specification, etc., were completed, and finance sought for the auxiliary compressor and its installation. In the meantime, a two-dimensional slotted test section was fitted in the main tunnel and its performance investigated.[11] Using this test section, operation up to $M \approx 1 \cdot 15$ was possible, but for limited periods only, since both the Merlin engine and the tunnel rapidly overheated.

While normal tunnel testing and the above pilot tunnel research was proceeding, tunnel cooling and strain gauge balance systems were investigated. In 1953, the external balance was dispensed with and strain gauge balances used for all force measurements. The original three-channel strain gauge measuring equipment was designed[12,13] and built by the tunnel staff and soon afterwards, a further three-channel set of Elliott self-balancing equipment was installed.

Tunnel cooling requirements were based on 50°C total temperature for the air leaving the cooler, and 2600 kW (3500 h.p.) maximum dissipation, plus the usual requirement of uniformity, control, etc. Although a refrigerated system, with its lower losses and bigger differential was the obvious choice, the capital cost plus other ARL requirements for a cooling tower, made it necessary to use cooling water supplied from a forced draught evaporation cooling tower situated towards the rear of the site.

Various cooling arrangements were investigated[14-18] to minimize losses due to the cooler, but it became clear that the area of the big section of the tunnel had to be increased. This allowed the use of standard commercial finned tube cooling elements, but required a wide angle diffuser upstream, and a new contraction downstream of the cooler. Model tests of the wide angle diffuser (Fig. 11) with artificially thickened boundary layer at the inlet showed satisfactory performance.[19] Since a new contraction was required, the opportunity was taken to increase the test section size to 0·53 m × 0·81 m (21″ × 32″) at the throat, which increased maximum model size and increased the maximum pressure ratio available from the compressor as a result of better matching. A new first diffuser was required.

In November 1956, the tunnel was shut down and was in operation again in less than 12 months. In this period, the tunnel shell was cut and the present cooling system, a new contraction,

test section and first diffuser were fitted, the Merlin drive was replaced with an electric one, a new control desk, multitube manometer and tunnel access door were installed, and the existing top hatch was extended to the mezzanine floor and a new lid fitted. The existing two-stage compressor was retained as it was hoped auxiliary suction would be provided. Later, when funds for a suitable compressor were not made available, the present four-stage compressor was built and installed.

4. PRESENT TUNNEL

The aerodynamic outline of the present tunnel is shown in Figures 12*a* and 12*b* while Figure 13, a photograph of a model, shows the layout of tunnel, drive, auxiliaries, control room, etc. All timber items within the tunnel, which made it very difficult to get a really dry tunnel in a short time, were removed. All the original corners underturned and have been replaced with 6 mm-thick aluminium vanes, designed in accordance with Dimmock's work,[20] and O'Brien's[21] experiments. For economic reasons, it was necessary to reduce the pressure rating of the tunnel shell, which is now rated at 0·2 atmospheres absolute pressure, and is protected by a blow-off diaphragm (see Fig. 12) and a pressure-actuated relay to turn off the main tunnel compressor.

Access to the test section is provided through a 1·8 m (6') diameter door shown being installed in Figure 14. This door travels horizontally, is pneumatically propelled, and is sealed with an inflatable seal, which is automatically deflated when the door opening solenoid is actuated. Operation of the door is also possible from inside the tunnel, but needs both mains power and air pressure, so to prevent accidental evacuation with people inside, an alarm bell, vacuum pump cutout, and an ordinary telephone are provided. The top hatch was extended to the mezzanine floor, and small elliptic manholes provide access where needed. The leakage rate is around 0·5 mm Hg per hour at 25 mm Hg absolute pressure.

Figure 12 also shows the shape of the wide angle diffuser, situation of cooler, screens and contraction, and installation of this section of the tunnel is shown in Figure 15. The cooling installation consists of two banks of commercial finned tube radiators, one 117 mm ($4\frac{5}{8}$") wide, the other 60 mm ($2\frac{3}{8}$") wide, both 8 fins inch, fin thickness 0·015", with a 3" (76 mm) gap between banks, and the local cross sectional area is 3·76 m by 3·5 m (12' 4" by 11' 6").

The contraction design[22] is similar to the early rectangular one but the inlet dimensions are now 3·3 m by 3·56 m (10' 10" by 11' 8") and the outlet 0·53 m × 0·81 m, the throat occurring in the test section downstream of the join between contraction and test section. The upstream part of the contraction was intended to be a permanent installation; the downstream part was intended to be of a temporary nature, and is of light aluminium construction. The two screens are 30 mesh. Although the original design called for auxiliary suction, porous-walled test section, flexible nozzle and the available two-stage compressor, funds for the auxiliary suction plant were not provided, and diffuser suction had to be used, with slotted test sections, and a four-stage compressor.

Two slotted, interchangeable test sections are used (Fig. 16); one is for two-dimensional aerofoils and has 0·4 m rotateable windows, which may be optical glass, in the solid side walls; the other is for three-dimensional testing, and of course one solid wall plus three slotted ones suits half models. Wall divergence and open area ratio are a compromise between supersonic performance and subsonic behaviour. A solid test section has also been constructed, and provides solid wall test section data when needed.

The first diffuser is shown in Figure 17, and the major part of it is designed to travel on rails downstream [illegible] thus bringing sting-mounted models clear of the test section, or providing access to models mounted off tunnel walls. In Figure 17 may be seen the motor-driven linkage which drives the diffuser, and in the running position a rubber seal provides an airtight seal between the inner and outer conical steel sections. The drive incorporates a spring and shear pin protection. Since the weight of the diffuser far outweighs any model lift, it is arranged to reach within about 6 mm of the end of the test section, no direct attachment being required.

Inlet to the diffuser is 0·946 m by 0·72 m and transition from rectangular to circular is shown in Figure 17, where it will be seen that the effective diffusion angle is very small. A sort of second throat is provided, the shape being laboriously developed, with the entry dimensions, to give maximum tunnel Mach number. Further improvement may well be possible (see Fig. 18).

The incidence change system for sting-mounted models is carried by the first diffuser, and is a vertical strut type, driven by a two-speed motor. Operation of a lever causes a gear change, and converts the mechanism to a traversing one. Angle of attack range is with uncranked stings, $\pm 15°$, and with cranked adapters can be extended to over 90°. Model rotation is about a point 0·457 m upstream of the end of the test section, with limit-switch protection to limit model travel. Remote indication is by Selsyns. A similar two-speed drive effects the rotation of the large windows.

The four-stage compressor shown in Figures 19 and 20 was designed[23] and built at ARL and has given very many trouble-free years of operation. It gives a pressure ratio of around 1·5 at 2200 r.p.m., produces a top Mach number above 1·4 (see Fig. 18), and is well matched to the tunnel.

The tunnel drive consists of a 1500 kW AC slip ring 6·6 kV induction motor with liquid rheostat speed control, in parallel with a 150 kW Ward Leonard set, both driving the compressor shaft through a common gearbox. Maximum r.p.m. are 2226 for the compressor corresponding to 371 for the main motor and 1470 for the DC motor. The latter, of course, provides precise speed control, braking and emergency shutdown. During emergency shutdowns power is delivered into a resistor bank. Operation is manual, with suitable protection, and maximum short-term power is 2050 kW. The liquid rheostat is cooled by forcing the electrolyte through a stainless steel heat exchanger, supplied with cooling water from a small tower of 750 kW rating, which provides cooled water for all the other plant requirements as well. Cooling of the main motor windings is by forcing filtered air into the motor core, and allowing it to exit past the windings and up the "chimney" fitted above the motor (see Figs 21 and 22).

Since the drive is operated entirely by remote control from the tunnel control room, it is essential to monitor temperatures of gearbox and compressor bearings, main motor windings, electrolyte, oil, cooling water, plus the usual pressures, motor currents, etc. Initially, temperatures were all indicated on millivoltmeters but in 1973 a DEC 8/F microcomputer was installed. It was interfaced and programmed to scan all these temperatures, and provide audible and visual indication if anything overheated. Red LEDs are used to show that scanning is taking place, and if a device overheats, that LED stays on so that the malfunction is located.

Since a large part of the tunnel's operation is at pressures below atmospheric (Fig. 23), it is desirable to be able to reduce tunnel pressure quickly. Similarly, for drying the tunnel it is necessary to reduce the tunnel to a very low pressure. Two vacuum pumps, JVE type PKS-060, are used as well as the original compressor. Actually, if tunnel pressure is reduced too rapidly with a "wet" tunnel, condensation occurs and moisture settles out on the steel, making it much harder to dry out the tunnel. Two drying towers are used, and each uses one-quarter "molecular sieves", three-quarters activated alumina. This effectively doubles the drying capacity of each tower compared with using activated alumina alone.

Tunnel instrumentation has been continually improved over the years. Both strain gauge balances[24] and electronic equipment for use with these balances have been developed for many years.[12,13,25,26] The equipment described in Reference 26 uses fundamentally the same system as the Elliott and White and Riches equipment it replaced. It is AC excited and self-balancing but has a sensitivity some 10 times better; being all solid state modern electronics is much more reliable, and occupies a fraction of the space previously required. A Mark II version is being developed which offers still further improvements.

Pressure measurements use a multitube manometer and/or scanivalves and pressure transducers.[27,28] The multitube manometer, now rarely used, was constructed using stainless steel, plastic, and 9·5 mm diameter glass tubing, and can use either mercury or "carbitol" with Sudan IV dye, as a working fluid. The increased tube diameter gives a flat miniscus, and "carbitol" ensures the manometer never needs cleaning. ("Carbitol" is the trade name for diethylene glycol monoethyl ether, density about 1, a viscous liquid with low surface tension and low vapour pressure so that it does not boil off at low pressures.) With present equipment, up to five scanivalves can be operated, stagger scanning up to 240 pressure points at speeds usually around 12 per second.

A 0·41 m diameter f/6 schlieren system is fitted, and this has recently been used in a laser-operated interferometer using a 4 W argon laser.[29] This seems a very practical arrangement, remarkably tolerant of tunnel vibration and operating conditions. Installation of a laser doppler anemometer is proceeding and it should be operating in the near future.

Static, total and base pressure have been measured for many years using Midwood[30] type automatic self-balancing capsule manometers. Solid state electronics have been fitted to these pressure balances using less space, giving better reliability and eliminating digitizers.[31]

However, the biggest advance in instrumentation was in 1968 when a dedicated, on-line minicomputer was installed. This was a DEC PDP8/I, with hardware multiply and divide, 12K of core, two small discs type DF32, two DEC tape transports, Calcomp 565 plotter, Potter LP3000 line printer, Tektronix 611 storage display, and ASR 33 teletype. This was interfaced to the tunnel instrumentation, and programmed with both hardware and software oriented to suit tunnel operation, and using previous work.[32-42] This installation is used for on-line computation, off-line plotting and cross-plotting of tunnel data, and for calibrating balances. It has improved tunnel efficiency and meant a large increase in time available for aerodynamics instead of tunnel operation. In operation, the time to set model attitude and adjust Mach number is unchanged and therefore so is the time to take one data point, despite the speed of the system. The large gains in efficiency arise because faulty data are quickly apparent, points are taken only when needed, and production of data ready for publication is expedited, hand plotting is eliminated, and so on. Of course, just as important are improvements in the quality of data produced and the fact that some previously tedious tasks, such as measuring pressure distributions, are made simple and fast.

The installation computes and displays free-stream Mach number about twice per second when any operating program is running. For pressure measurements, scanning is started and stopped under program control, and both pressure coefficients and the ratio of local static to total pressure are computed, and printed and stored along with the raw data. Computed values may be plotted on-line if desired, and under teletype control either pressure coefficients or the above ratios may be draw on the display for inspection and photographing if desired. For force and moment measurements, the system may operate in "Look" or "Record" mode, the meanings being self-evident. This display shows coefficients computed using first strain gauge balance zeros, and may be zoomed, shifted left-right, up-down, and plots coefficients versus Mach number or either model attitude angle, under teletype control. Also coefficients may be deleted, for greater clarity, and the display photographed with a Polaroid camera. In "Record" mode, raw data are printed and stored, and when final strain gauge zeros are taken, the data are recomputed, printed and stored. Raw data can be recomputed using other programmes, allowing for changes in balance constants, if needed, and other programs permit editing data, and so on.

The installation has, over the years, grown to 24K of core, a FACIT line printer, two floppy discs, an ASR43 teletype, an RKO5 large disc, and a high-speed paper tape reader. However, the basic installation is approaching the end of its life, and in addition the initial requirement to provide on-line computed coefficients and eliminate hand plotting, has long been outgrown. Therefore, the need for a machine of much greater power and with much increased storage has been apparent for several years.

For the measurement of dynamic derivatives a "Dampometer"[43] has been constructed, while another minicomputer, a DEC 8/A is used in an inexorable oscillating rig, which has been under development for some time. The 8/I computer is also interconnected to the 8/F mini previously mentioned in connection with plant monitoring. This allows program transfers, but was intended to provide data transfers as well, leading to operation at constant Mach number, constant model attitude, etc., and using the 8/F to control these variables. To date, only model roll can be controlled by the 8/F.

The tunnel control room is shown in Figure 24 where the major items of equipment can be seen. For normal operations, only two people are required to operate the tunnel, with no-one in the motor room.

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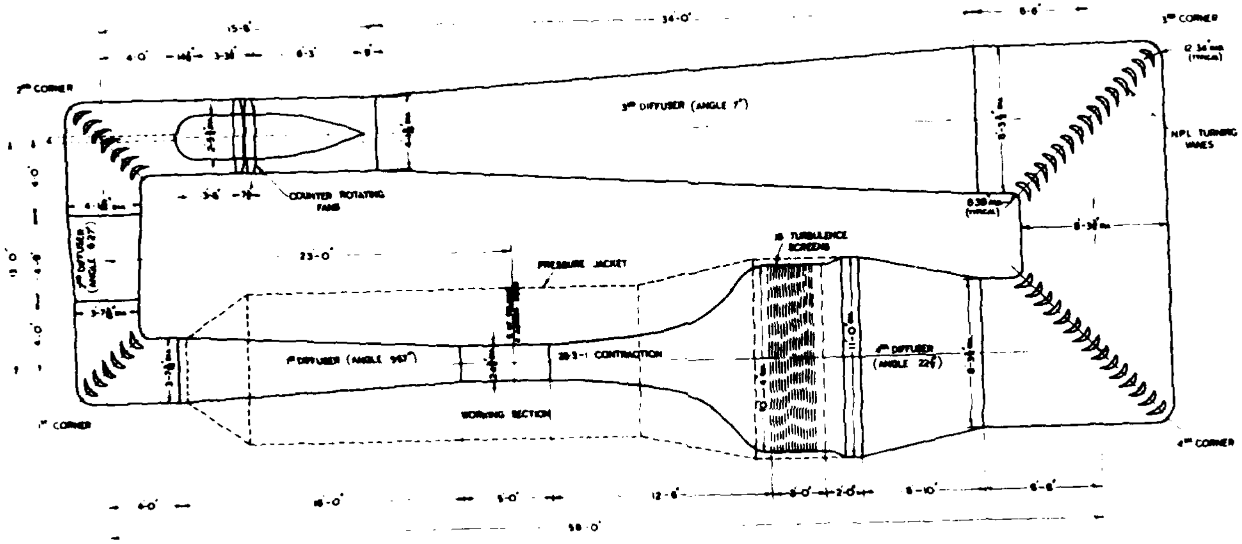


AERODYNAMIC OUTLINE
C.S.I.R. VARIABLE PRESSURE WIND TUNNEL

FIG. 1. AERODYNAMIC OUTLINE OF ORIGINAL TUNNEL

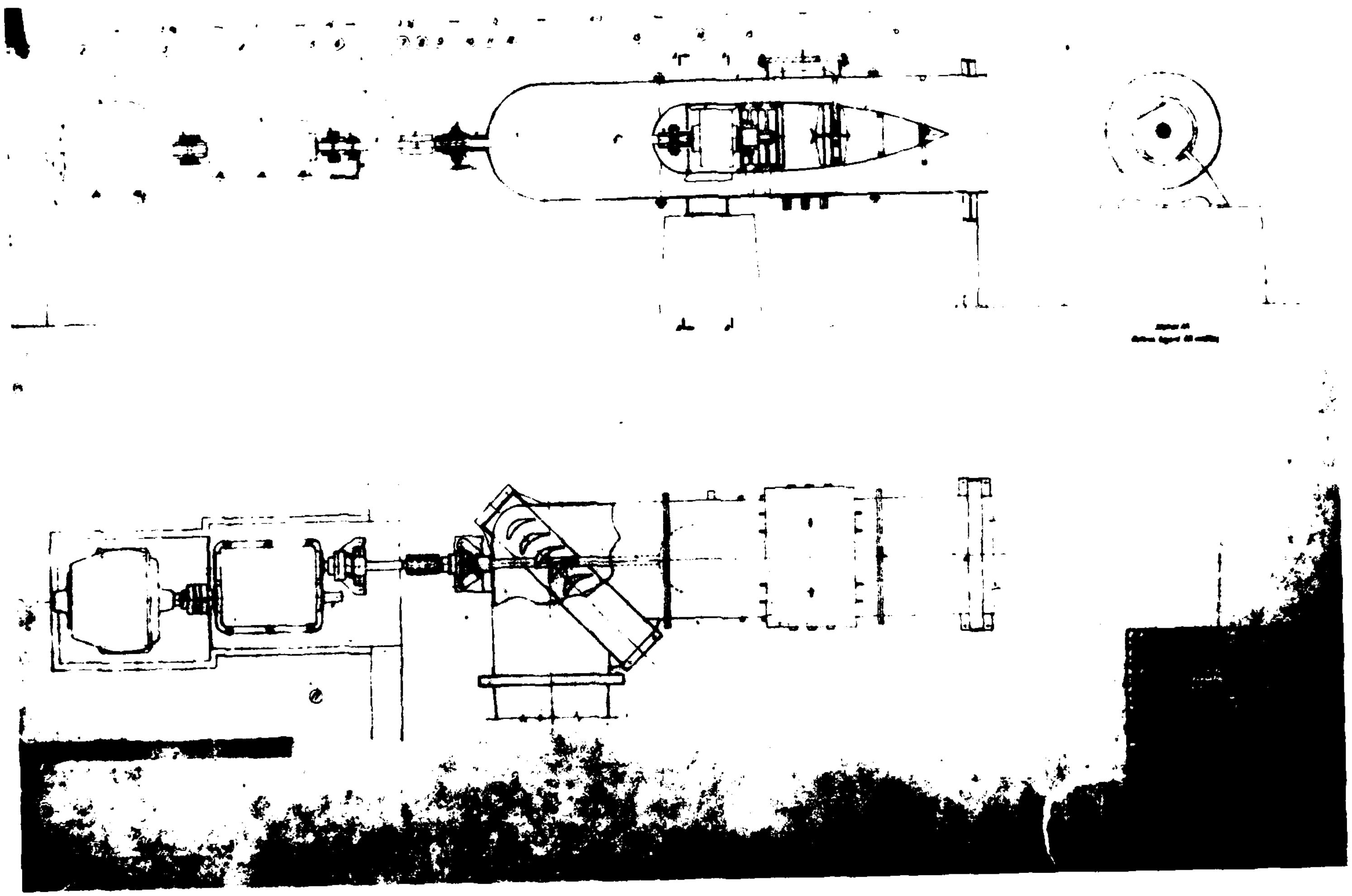


FIG. 2. ORIGINAL TUNNEL DRIVE ARRANGEMENT

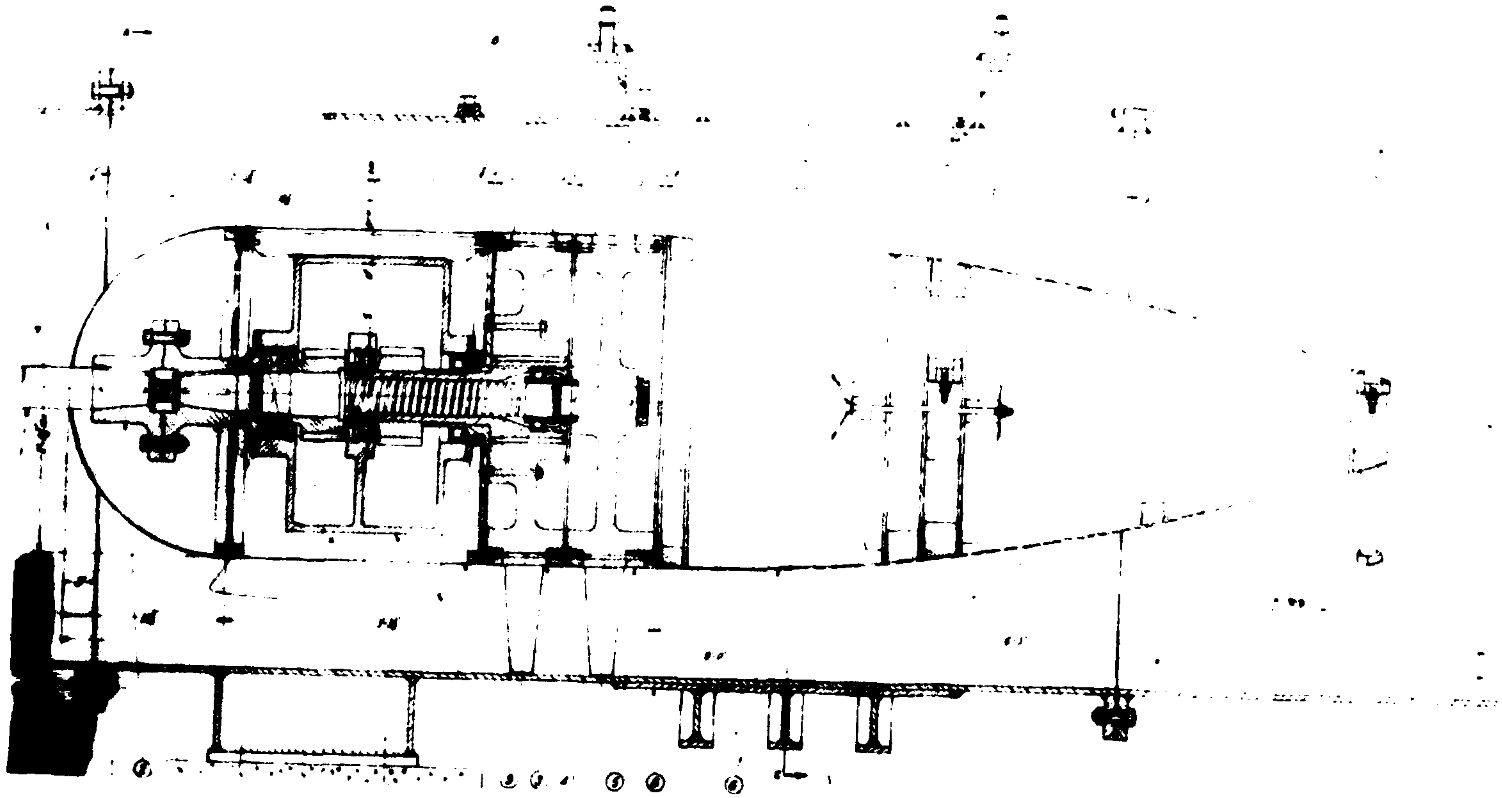


FIG. 3. ORIGINAL TUNNEL CONTRAROTATING FAN

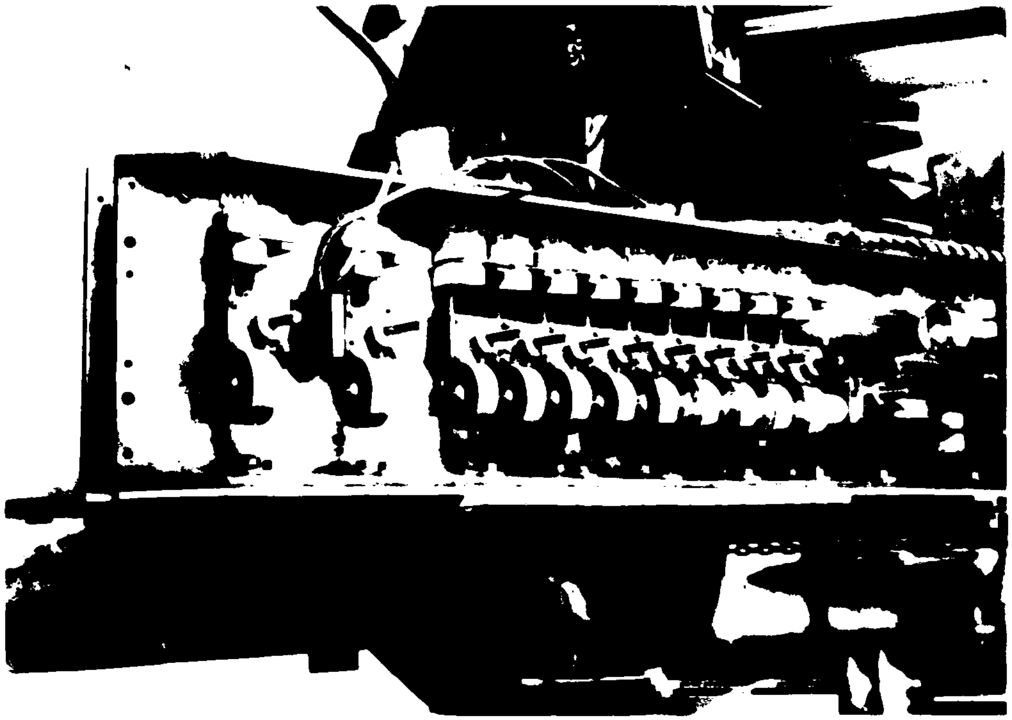


FIG. [illegible]. ORIGINAL TUNNEL FLEXIBLE WALL DURING CONSTRUCTION

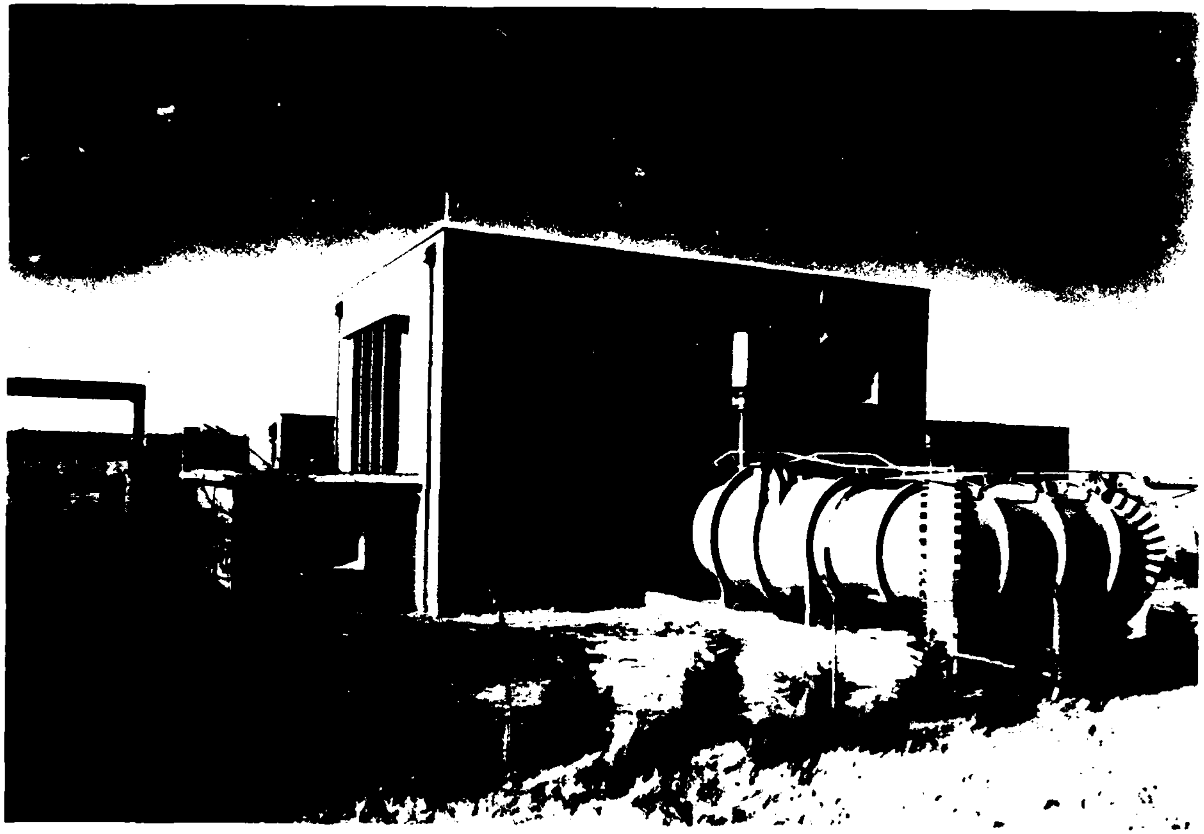


FIG. 5. ORIGINAL TUNNEL EXTERNAL VIEW

FIG. 6. ORIGINAL TUNNEL – U TUBE MANOMETERS

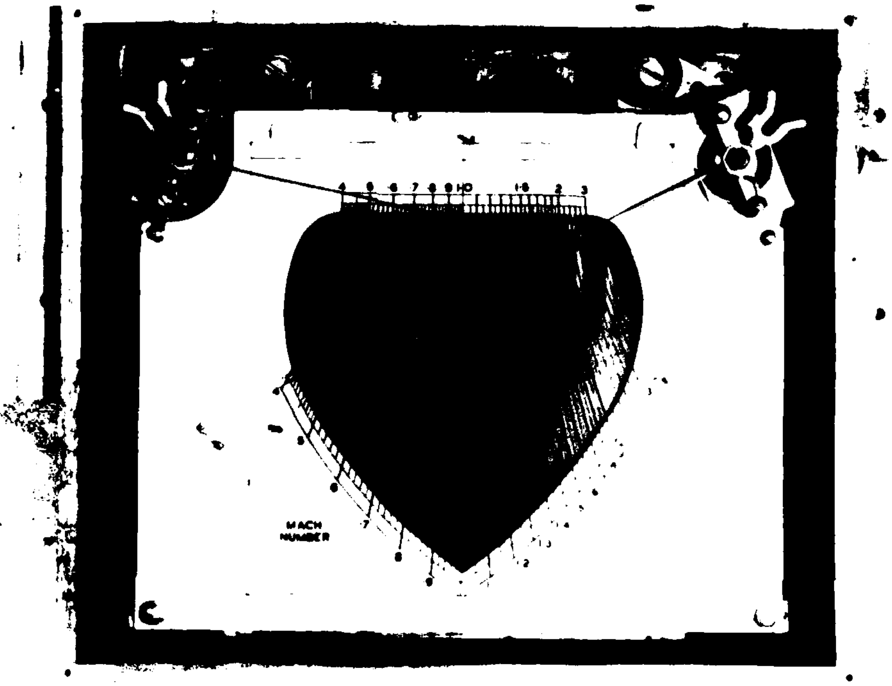


FIG. 7. TYPICAL RATIO METER WITH COVER REMOVED

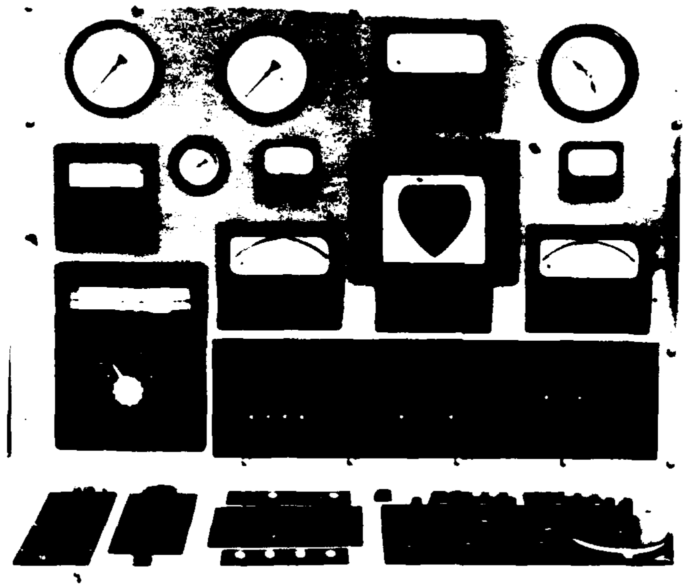
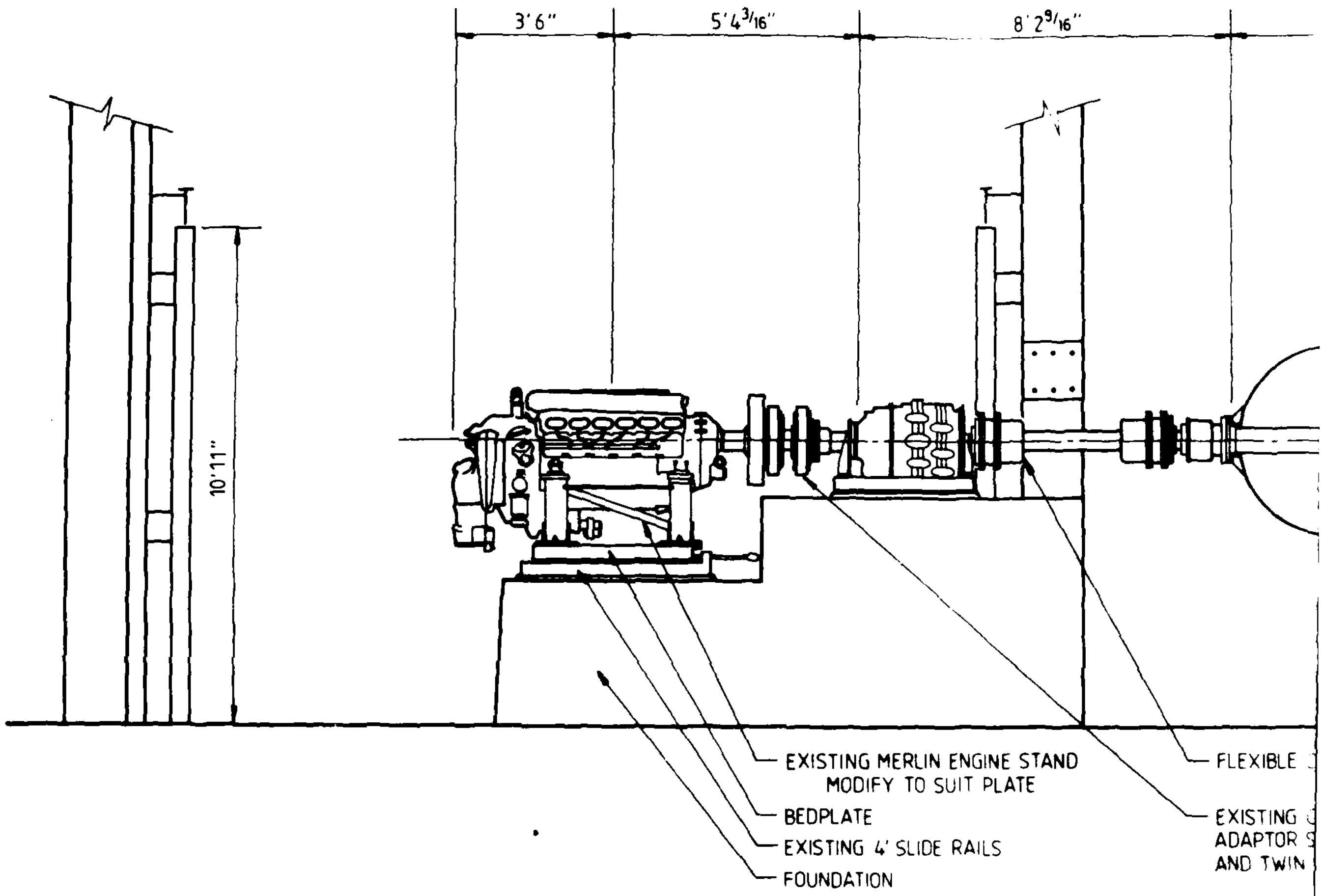


FIG. 8. ORIGINAL TUNNEL – PART OF CONTROL DESK

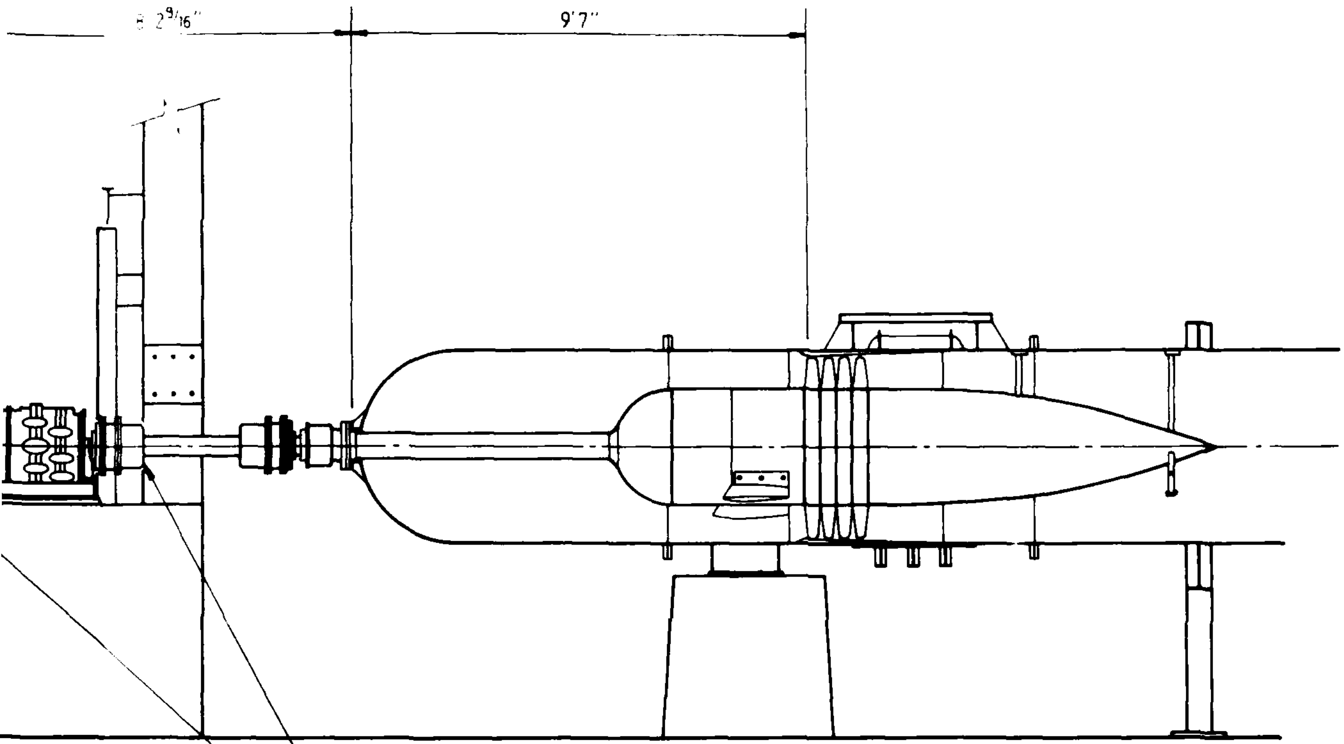


ROLLS ROYCE MERLIN ENGINE

MAX POWERS (LOW BLOWER GEAR)

RATING	B HP	RPM	BOOST PRES
CONTINUOUS	1080	2690	+7 LBS/IN
20 MIN	1225	2850	+2 LBS/IN
5 MIN	1420 - 1480	3000	+14 LBS/IN

FIG. 9. TE



ROLLS ROYCE MERLIN ENGINE
(LOW BLOWER GEAR)

B.HP	R.P.M.	BOOST PRESS.	MERLIN PROP. SHAFT SPEED	FAN SHAFT SPEED
1080	2690	+7 LBS/IN	1117 R.P.M.	1670 R.P.M.
1225	2850	+2 LBS/IN	1198 R.P.M.	1797 R.P.M.
1420 - 1480	3000	+14 LBS/IN	1260 R.P.M.	1890 R.P.M.

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FIG. 9. TEMPORARY DRIVE ARRANGEMENT

FIG. 10. MERLIN ENGINE, GEARBOX AND EXHAUST

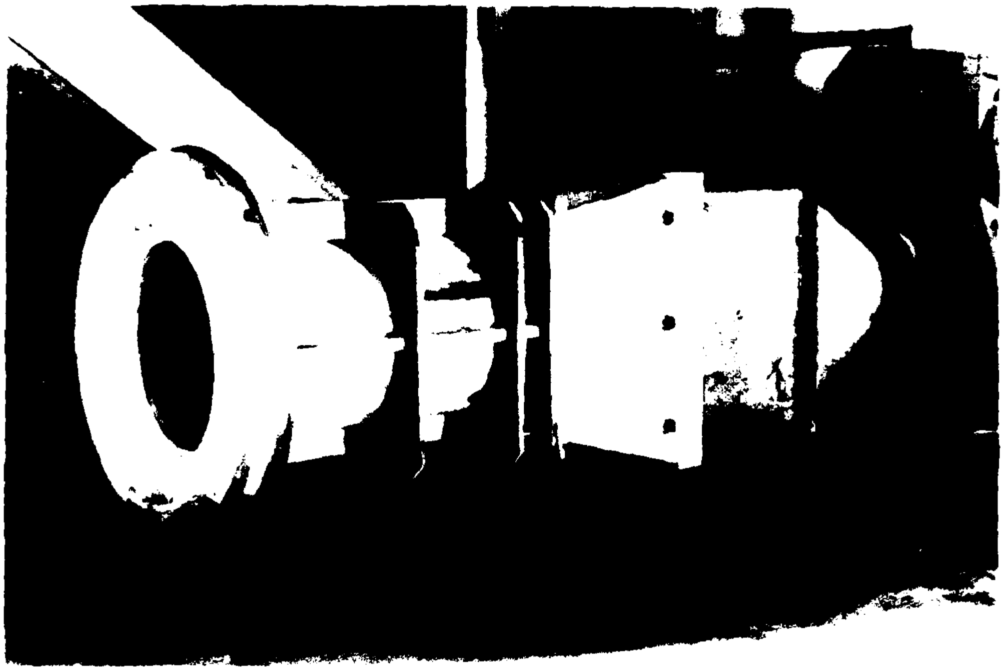

FIG. 11. WIDE ANGLE DIFFUSER TEST RIG

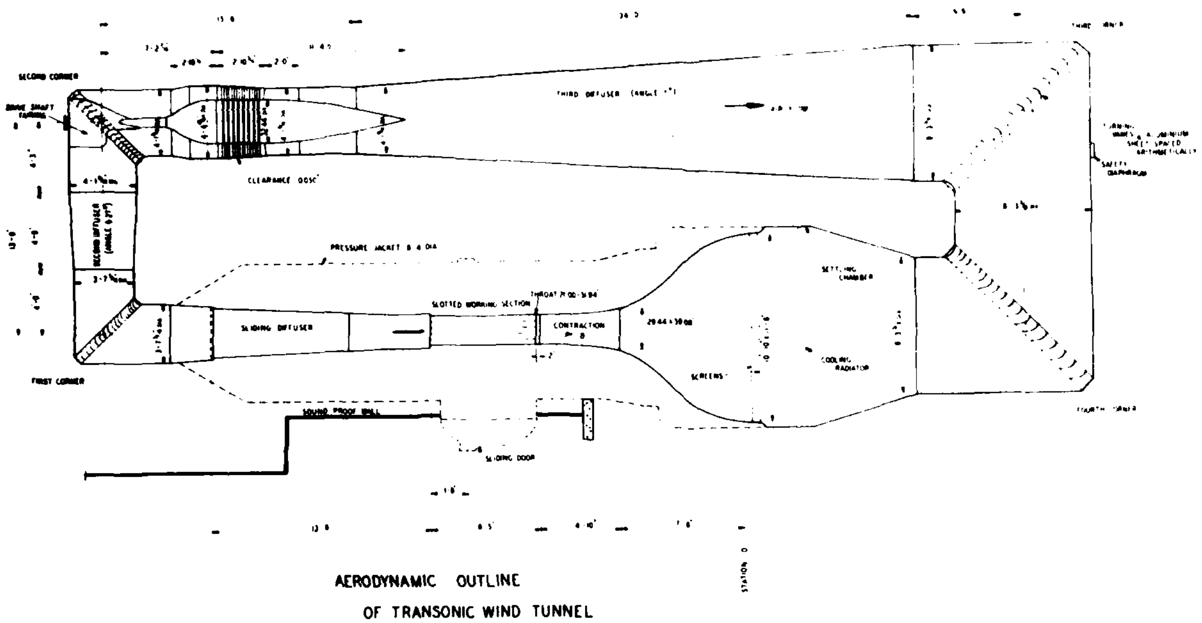

FIG. 12 (a). AERODYNAMIC OUTLINE OF TRANSONIC TUNNEL

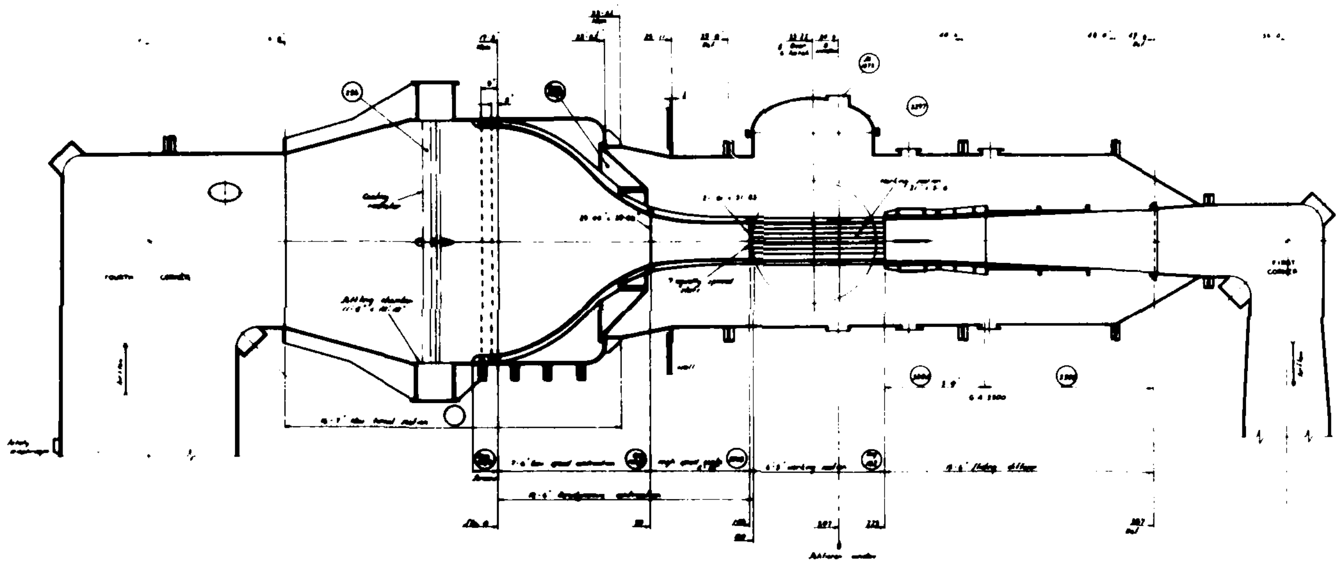

FIG. 12 (b). AERODYNAMIC OUTLINE AND SOME DETAIL

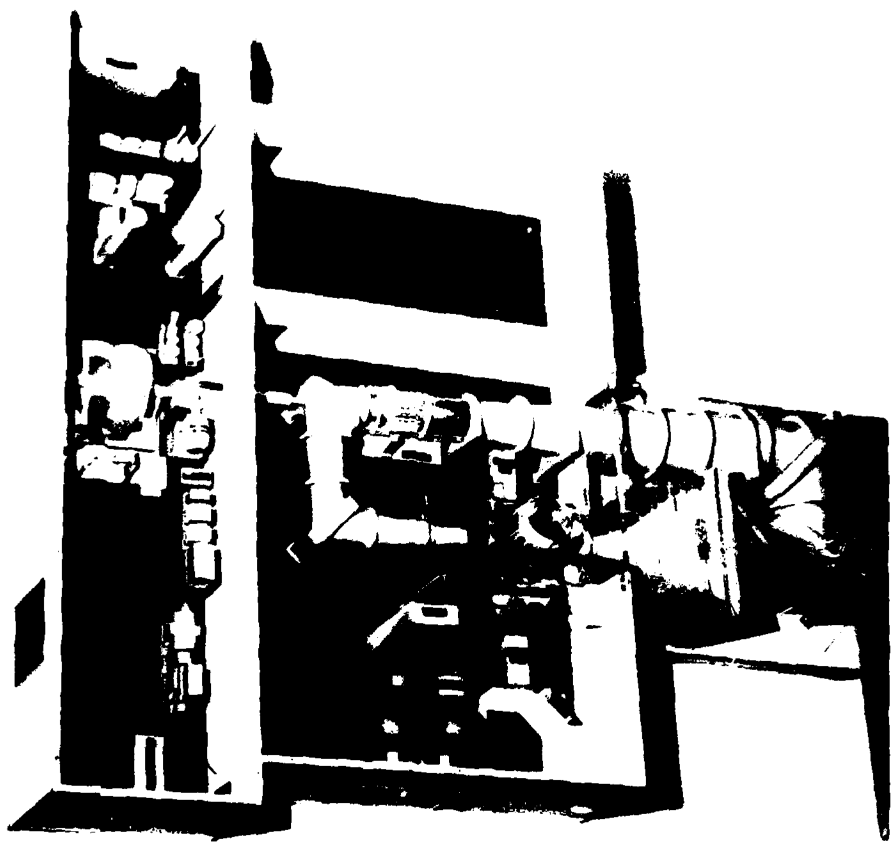

FIG. 13. ARRANGEMENT OF TUNNEL, MOTOR ROOM & CONTROL ROOM

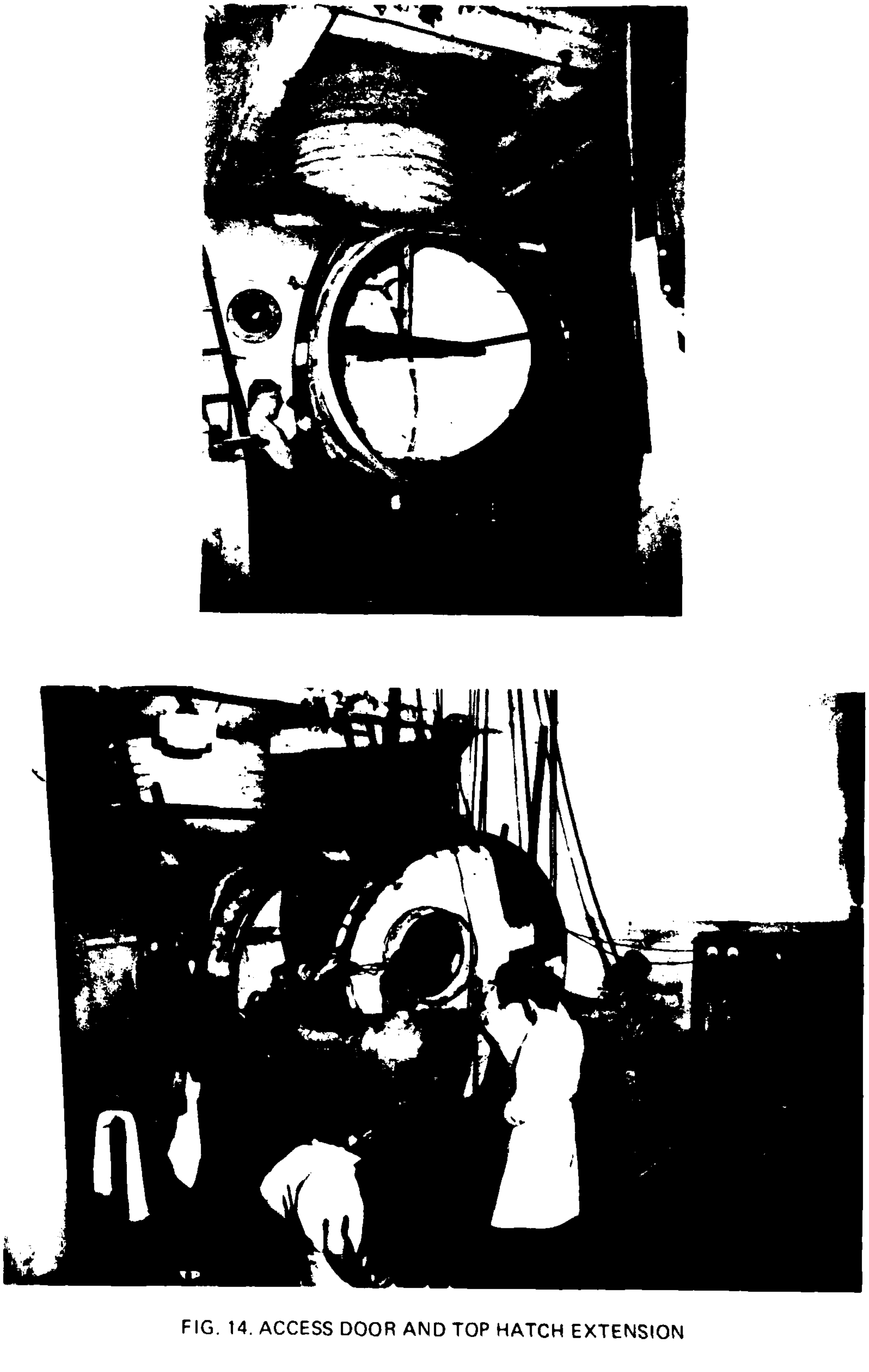

FIG. 14. ACCESS DOOR AND TOP HATCH EXTENSION

FIG. 15. INSTALLATION OF COOLING

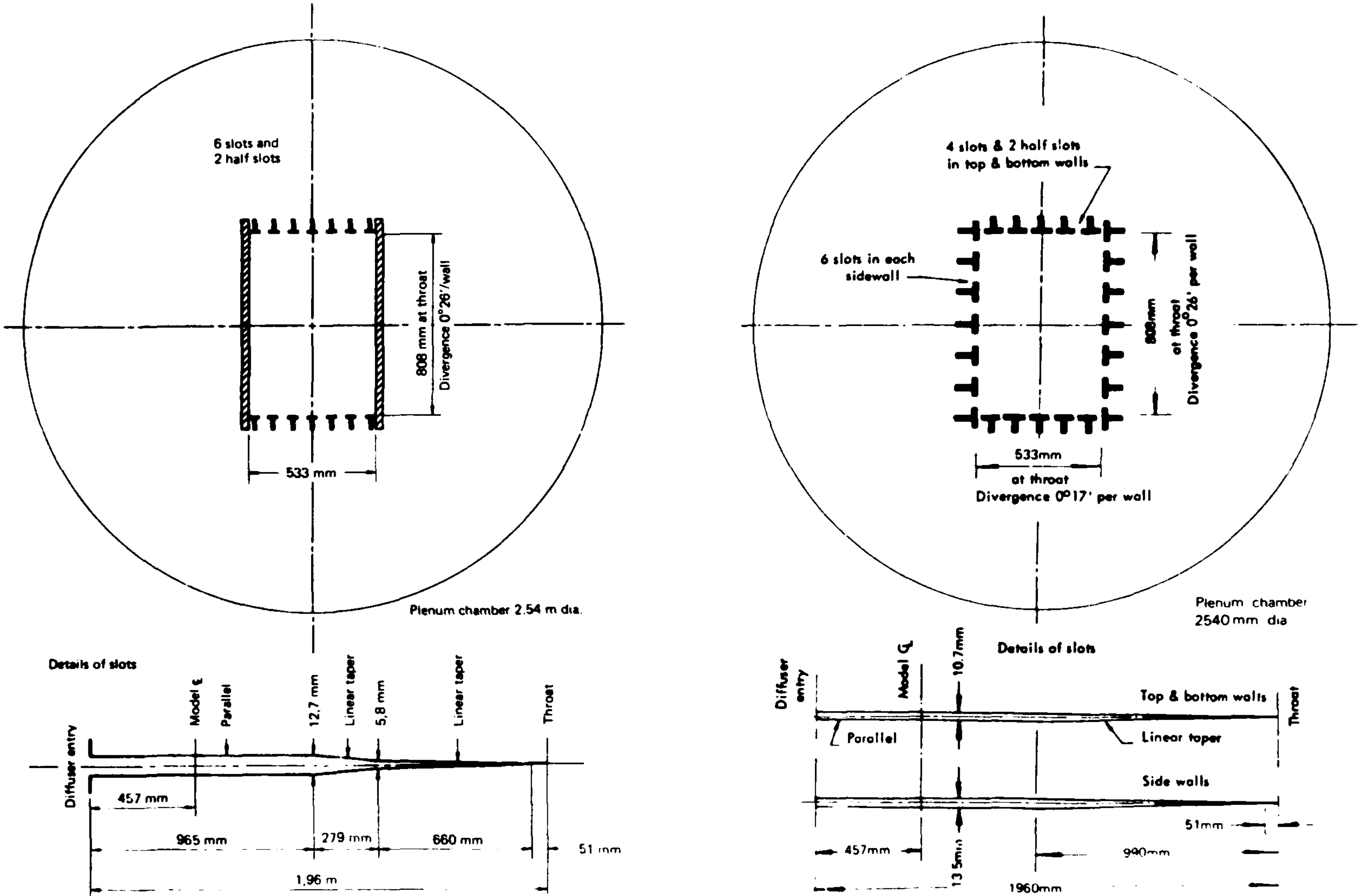

FIG. 16. SLOTTED TEST SECTIONS

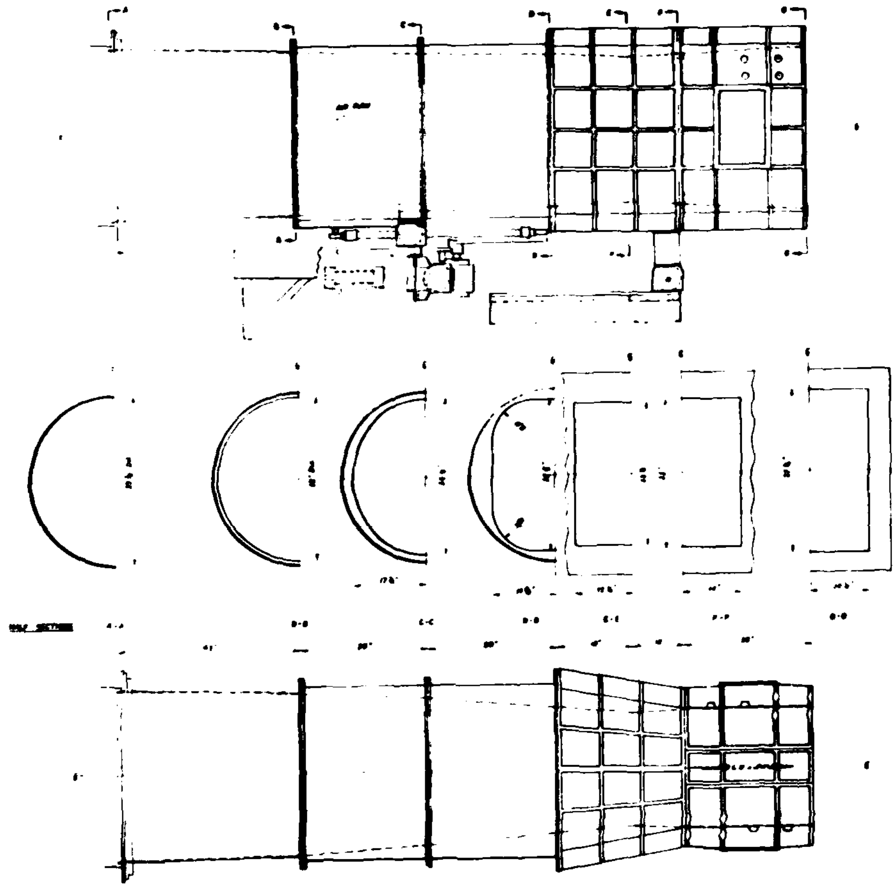

FIG. 17. FIRST DIFFUSER

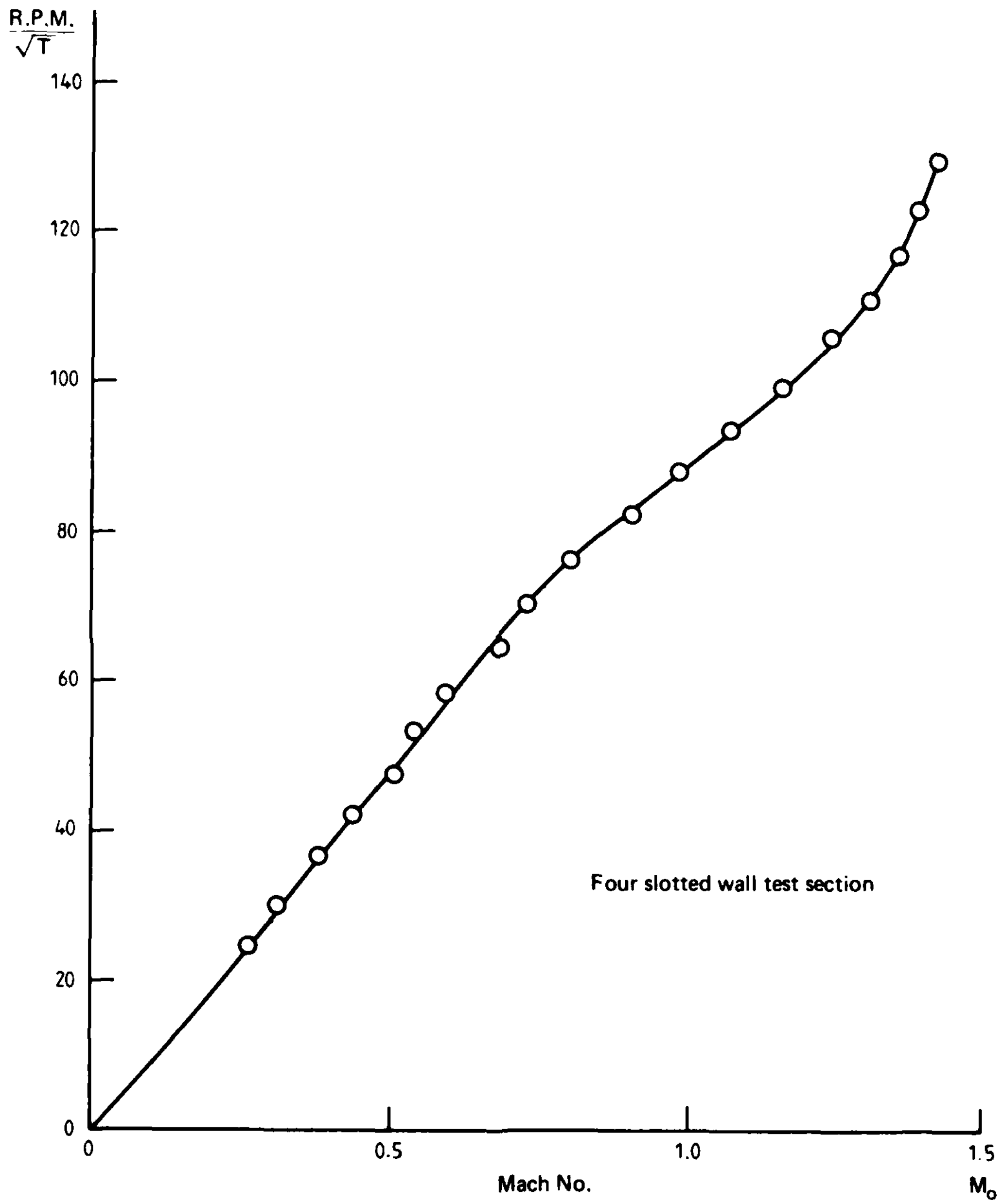

FIG. 18. FALL OFF IN MACH NO. WITH R.P.M.

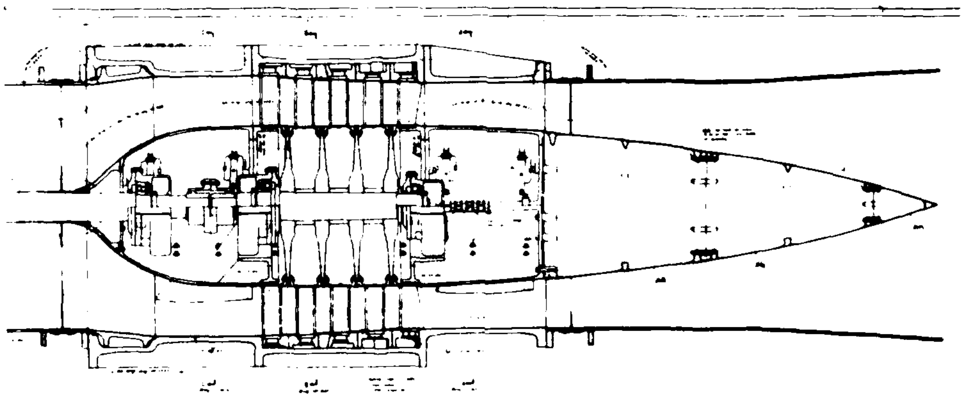

FIG. 19. FOUR STAGE COMPRESSOR

FIG. 20. FOUR STAGE COMPRESSOR

FIG. 21. MOTOR ROOM SHOWING MAIN MOTOR, GEARBOX, & MAIN MOTOR COOLING

FIG. 22. MOTOR ROOM SHOWING LIQUID RHEOSTAT, ELECTROLYTE HEAT EXCHANGER AND PART OF WARD LEONARD SET

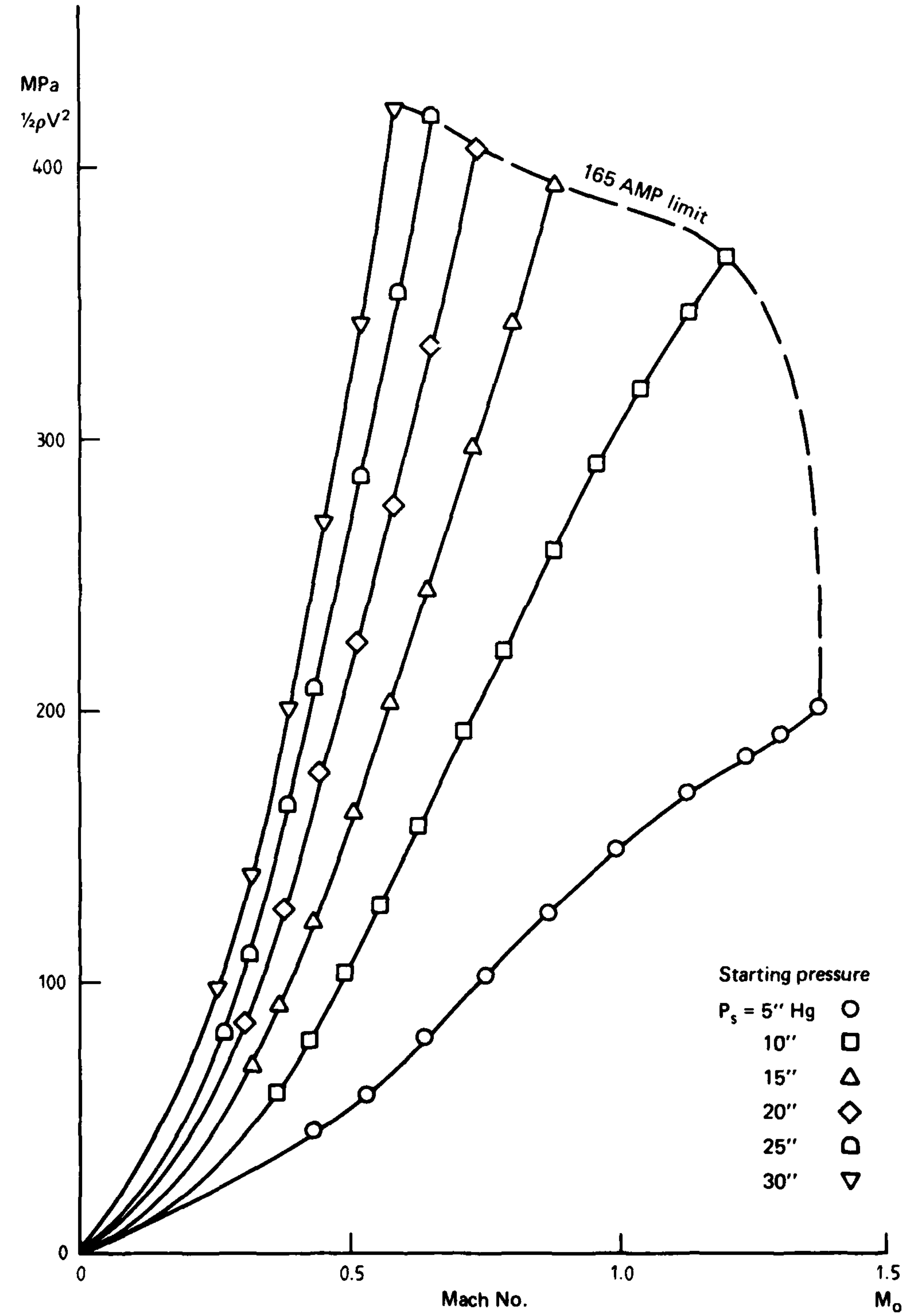

FIG. 23. STARTING PRESSURE vs MACH NUMBER

FIG. 24 CONTROL ROOM

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16. Abstract

The ARL transonic wind tunnel is described. Originally built as a conventional subsonic high-speed tunnel it was converted in 1957 to transonic operation, and has been in operation since that time.

It is a continuous flow, closed circuit tunnel with an electric drive system whose maximum power input is 2050 kW. The test section is 0·81 m high and 0·53 m wide. It is fitted with slotted walls and uses diffuser suction, covering a Mach number range of 0·4 to 1·4.

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